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ABSTRACT

In an increasingly technological society, there is a social need for designing communication technology around the perceptual abilities and cognitive strategies of people. A growing demand for information has created additional pressure on emerging communication technologies to provide electronic alternatives to the printed page. Design depends upon contributions from engineering and computer science, experimental and applied psychology, and graphic art and typology. A common, underlying theoretical assumption is that the reading of an electronic text may be influenced by characteristics of its visual presentation. Theory should converge on issues affecting readers of both the printed page and the electronic display. The features of a theoretical framework for research on the electronic book are the reading environment; the relationship between the author and the reader; and the readability of the text, its characteristics as a visual medium, and the reading level of the reader. In developing electronic books, a system is needed for research to examine relationships between textual material, communication technologies, and the psychology of readers. Twenty-nine references are listed. (Author/LMM)

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ELECTRONIC BOOKS:
TOWARDS A THEORETICAL FRAMEWORK FOR RESEARCH

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Abstract

In an increasingly technological society there is a social need for designing communication technology around the perceptual abilities and cognitive strategies of people. Growing information demand has created additional pressure on emerging communication technologies to provide electronic alternatives to the printed page. As prose is still the most widely used method of educational communication, theory should converge on issues affecting readers of both the printed page and the electronic display. In developing electronic books there is need for a system within which research may examine relationships between textual material, communication technologies, and the psychology of readers.

Introduction

A new technology of communication is being created which should stretch beyond printed paper. Design depends on contributions from engineering and computer science, experimental and applied psychology and graphic art and typography (see Figure 1). Underlying the varying positions is one common pretheoretical assumption: reading of electronic text may be influenced by characteristics of its visual presentation.

The electronic book may not only replace much of what would have been printed, but stands by the side of what has been

printed and eventually comes into being as its own authentic communication medium. Beyond the economic pressures to evolve, the electronic book may offer authors new ways of conveying meaning. It may allow readers new control of text by organization similar to database structure. This would be the ultimate goal: to eliminate impediments which designers place between authors and readers. There will no longer need be a silent intrusion by the technology of text (Yeaman, 1984).

The features of a theoretical framework for research on the electronic book are the reading environment, the relationship between the author and the reader, the readability of the text, its characteristics as a visual medium and the reading level of the reader. The most reliable and valid measures of reading efficiency are listed in the center of Figure 1. This paper focuses on the determination of legibility, towards examining the relationships between engineering, psychology, the graphic arts and education in contributing to the development of the electronic book.

Screen Reading Technology

The long and close viewing of electronic display screens is no longer the rare occurrence it once was when the initial applications were in the military, in navigation and in air traffic control. Such displays are currently supplanting the printed page and the predominant viewing task has changed from character recognition and identification to word processing and reading (Cohen & Carlson, 1980). The increase in CRT use in particular has raised concern about personal health by labor and government

agencies in a number of countries. Potential hazards investigated so far include radiation emission, airborn chemical contamination, workstation dimension, reflective glare and psychological distress (Rupp, 1981).

The engineering standards for the transmission of high quality images come from broadcast television (Cohen & Calson, 1980). The major criterion is resolving power for fine detail (Snyder, 1973). Gould (1968) refers to the 1941 FCC decision that television should equal 16mm movies in average condition and show 200,000 half-tone dots.

Display engineers claim to have accounted for legibility with objective measures intended to evaluate the alphanumeric quality of CRTs for their earlier uses. Sherr (1979) operationalized legibility for engineers as the quantity of correct identifications made by the display's readers. Laboratory testing with human subjects has resulted in prescriptions for minimum character height (Shurtleff, 1980).

However, through the use of instruments generating and evaluating sine waves, observations are most commonly made independent of direct psychophysiological consideration. Human judgement is not required at all. Sherr (1979) considers this to be objective whereas human observation is undesirably subjective. Though conceding the attractiveness of psychometric techniques, he claims sufficiency would require excessively costly and time-consuming total system simulation.

The measure preferred by engineers to estimate human visual performance is called the modulation transfer function (MTF).

The display resolution is analyzed with a sine wave test signal (Biberman, 1973). Sine wave response across a CRT spot is moderated by changes in beam current, focus and off-axis conditions and is described by an algebraic equation of harmonics known as a Fourier transform (Sherr, 1979). The only human element in the equation is normal visual acuity taken as 50% detection probability with approximately 230 lines per inch displayed at 100ft-Lamburts viewed from 25 inches and an angle of 1 minute of arc. In MTF equations normal acuity is assumed and given a standard value of one (Biberman, 1973). Banbury (1982) describes this machine model of human perception as the golden eye. While human vision and screen parameters may be discussed in common terms by looking at spatial frequency variation, MTF applies to picture recognition much better than it does to the recognition of dot matrix alphanumerics (Rogowitz, 1983).

Cakir, Hart and Stewart (1980) warn their readers about the minimal testing of display legibility with human subjects. When it does take place, reading performance is usually quantified as accuracy of recognition of letters or single words; whether or not B is clearly distinguishable from R, S and 8. The variables in such a visibility test may be distance, character size and style or brightness and spacing. Procedures for such testing are spelled out by Shurtleff (1980).

Reading Psychology

Reading performance as a psychological construct is based on the task of reading, and the preferred geometry or photometry of single letters does not provide a base for judging legibility as

a measure of reading. A link with ergonomics research on television and radar viewing may not be applicable to reading text from electronic displays because the task is different, i.e. distinction of fine detail does not guarantee legibility. For instance, dot-matrix letters, like the ones on this page, resemble the spots of color in a pointillist painting which require blending by the viewer's eye. Dot matrix characters can be read when sufficient detail is lost that the image of continuous strokes is seen. Enough detail must remain so that individual letters are not confused. Air traffic controllers learn to recognize special alphanumerics with a high discrimination and a low confusion rate between characters. The nature of their task differs from the one accomplished by readers of this sentence.

The advantage of extracting meaning by reading words over identifying individual letters is well established in reading psychology and was first demonstrated by Cattell who used a special flash card apparatus (1885). Single letters were named more slowly than short words and identification time for words was not proportionate to their length. This finding has been replicated many times in subsequent research on reading but its meaning is still debated (Dunn-Rankin, 1978; Wright, 1980).

Contrary to the engineer's point of view, text legibility involves the complexities of reading and is a cognitive issue. Thus, perceptual factors do not encompass all of the human factors involved in reading from CRTs. From the visibility of text it cannot be inferred that the text is acceptable to read without strain (Tinker, 1966).

Empirical Studies in Typography

Typographic research shows text legibility decreases when empirically based type conventions are disregarded. Letter size, line length and interline spacing are the major variables associated with lower comprehension, slower reading speed and inefficient eye movements (Tinker, 1965). The technology of electronically displayed text requires substantiation similar to that for printed text (Yeaman, 1984).

A contemporary paradigm for typographical research has been assembled by Bell and Sullivan (1981): "A cognitive/affective change occurs in a reader when personality/interest/reading style etc. characteristics encounter the imperative/recreational/advisory purpose of the material" (p. 57). It also may be defined as the ergonomic study of visually presented information displays (Foster, 1973).

Applications

The efforts of graphic designers towards developing screen formats for text have concentrated on data entry (Galitz, 1982), videotex and teletext (Reynolds, 1979, 1982) or interactive videodisc (Bork, 1981; DeBloois, 1982). Their typographic principles stem from the rational foundations of programmed learning texts: spacing for emphasis, color coding to convey meaning, short paragraphs to prevent intimidation of the students and so on. Aesthetic preferences are also a factor.

Instructional Technology

Jonassen (1982) states the purpose of the technology of text is to focus "on how written discourse can be most effectively presented" (p. ix), whether on the printed page or the electronic display screen. It is the "application of a scientific approach to text design" (p. x) and is rooted in the paradigm of instructional technology (Heinich, 1970). Implicit techniques relate to the organization of content as ideas. Explicit techniques such as advance organizers or graphic signals provide external indication of the text structure. These ideas do not extend beyond directly instructional purposes to encompass more general reading.

Synthesis

From the standpoint of theory building, Roufs and Bouma (1980) present a working philosophy. Both hardware engineers and visual researchers need to examine the connection between the characteristics of the observer and the visual image requirements in order to assure that the display peforms its function properly. Though technical and economic pressures cause display design choices to be made hastily, cooperation between the two groups would be of benefit. This joint endeavor would further vision theory and solve practical problems such as assessing the reader's ability and nature of the task, both previously neglected. Considerable international interest in this area has been shown recently by two conferences on Processing of Visible Language (Kolers, Wrolstad & Bouma, 1979, 1980) but interdisciplinary research remains rare.

Conclusion

Books of printed paper developed over a period of hundreds of years. All manner of corrections have been attempted in printed book design and production to develop a psychophysical fit in answer to empirical, rational and intuitive questions weighted against aesthetic and economic factors. There is not time for trial and error development of the electronic book. An effort must be made to build cognizance in special consumer research communities, such as education, that reading of text displayed on screens requires attention to technological/psychological problems which may otherwise be neglected.

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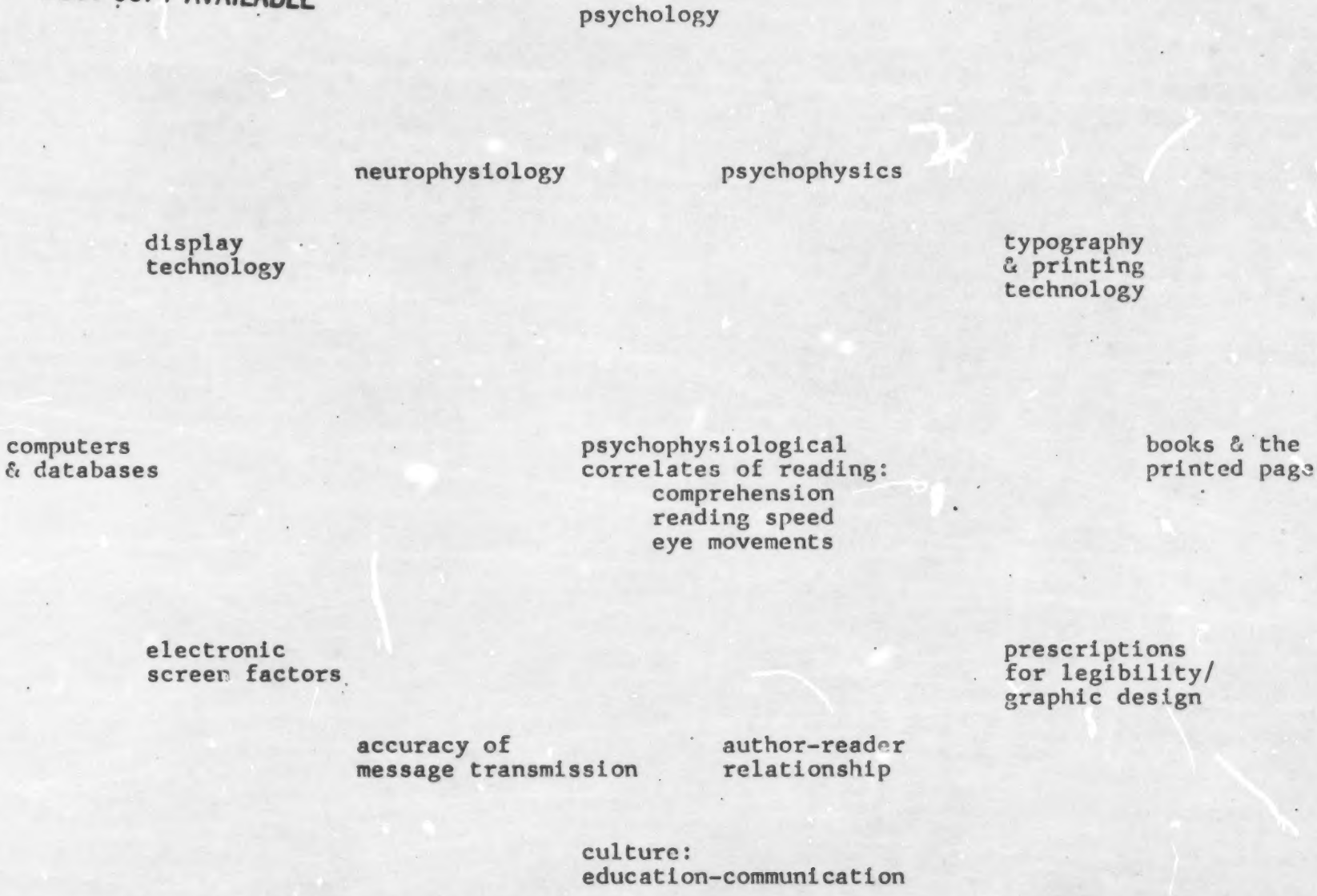

Figure 1: A viewfinder for developing electronic books.